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(54) **WRITE TRANSDUCER HAVING A MAGNETIC BUFFER LAYER SPACED BETWEEN A SIDE SHIELD AND A WRITE POLE BY NON-MAGNETIC LAYERS**

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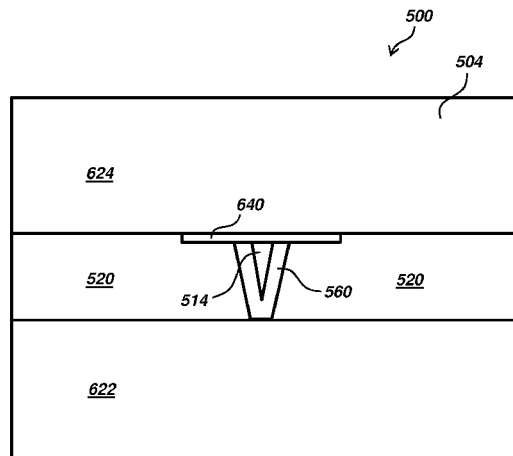
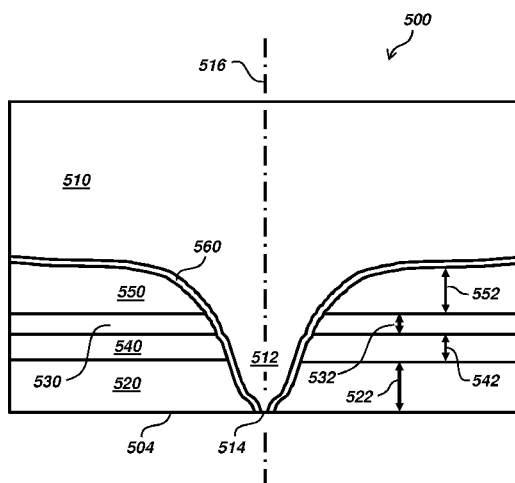
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(57) **ABSTRACT**

A write transducer for a disk drive magnetic head includes a ferromagnetic write yoke having a write pole protruding towards an air bearing surface. The write transducer also includes a ferromagnetic side shield, and a ferromagnetic buffer layer disposed between the write yoke and the side shield. A first non-magnetic layer is disposed between the side shield and the ferromagnetic buffer layer. A second non-magnetic layer is disposed between the ferromagnetic buffer layer and the write yoke. The ferromagnetic buffer layer extends in a direction normal to the air bearing surface by a buffer layer throat height in the range of 10 nm to 500 nm. In certain embodiments, such a write transducer may advantageously reduce undesired wide area track erasure, without unacceptably degrading write field rise time for acceptable on-track writing data rate.

24 Claims, 7 Drawing Sheets



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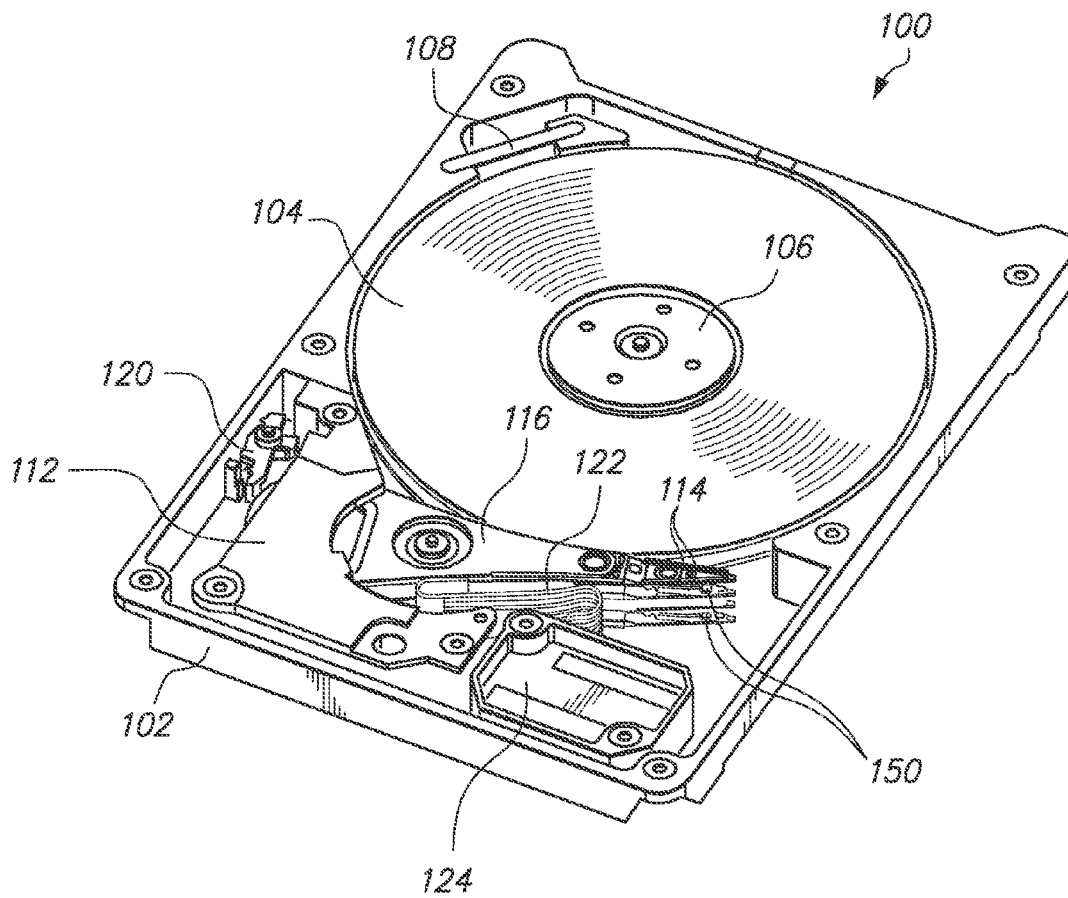
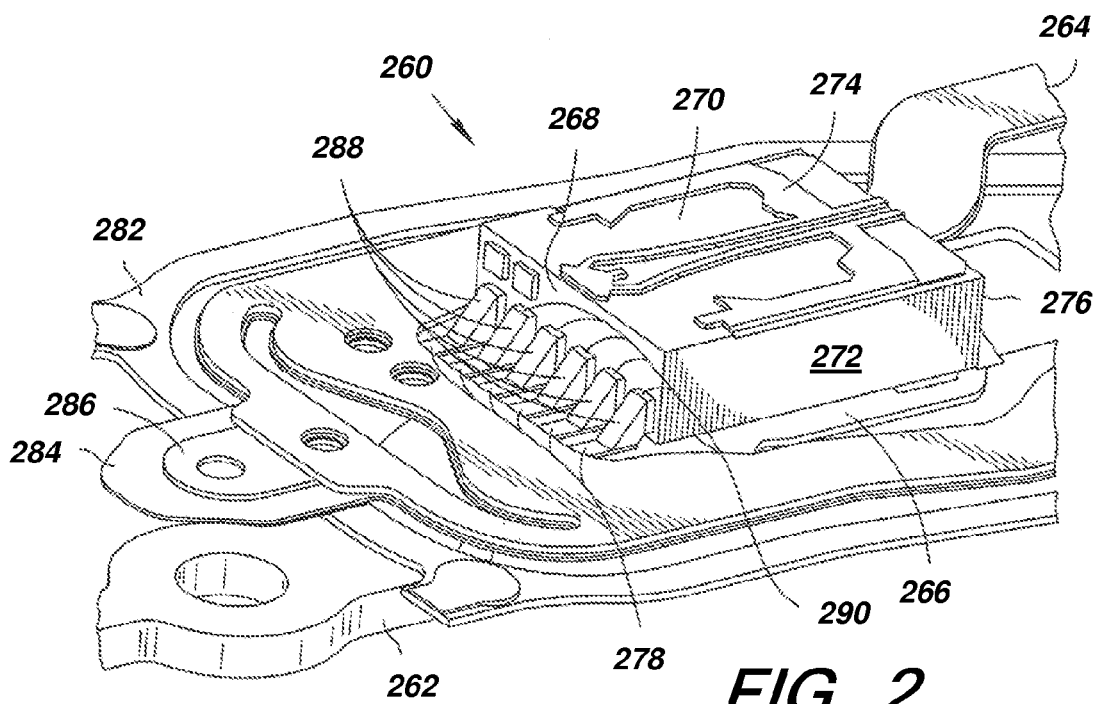


FIG. 1



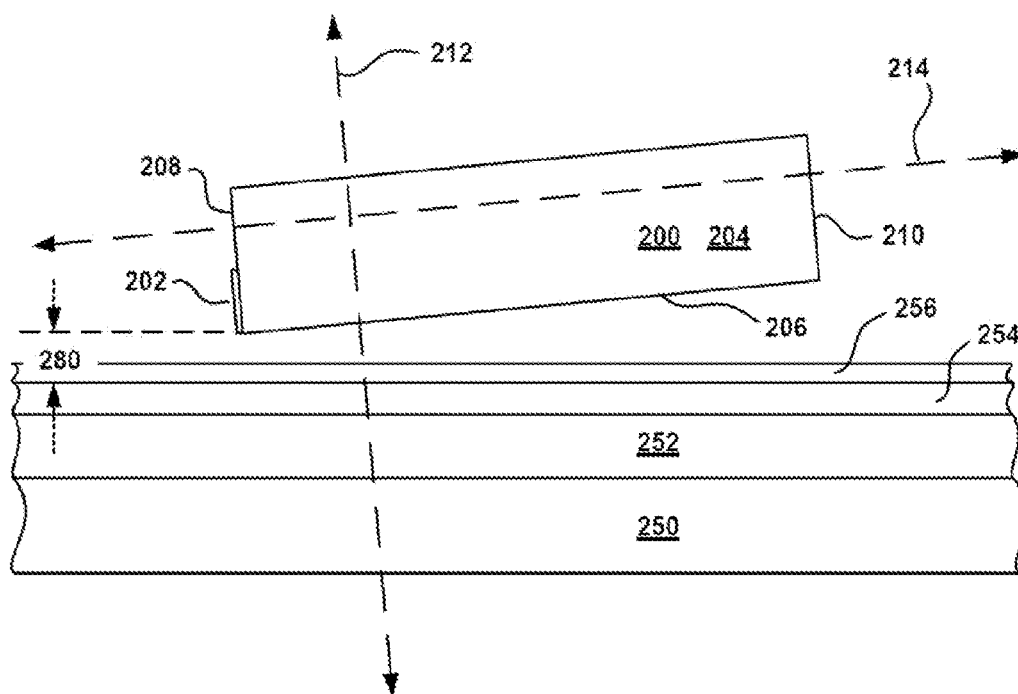


FIG. 3

FIG. 4
(PRIOR ART)

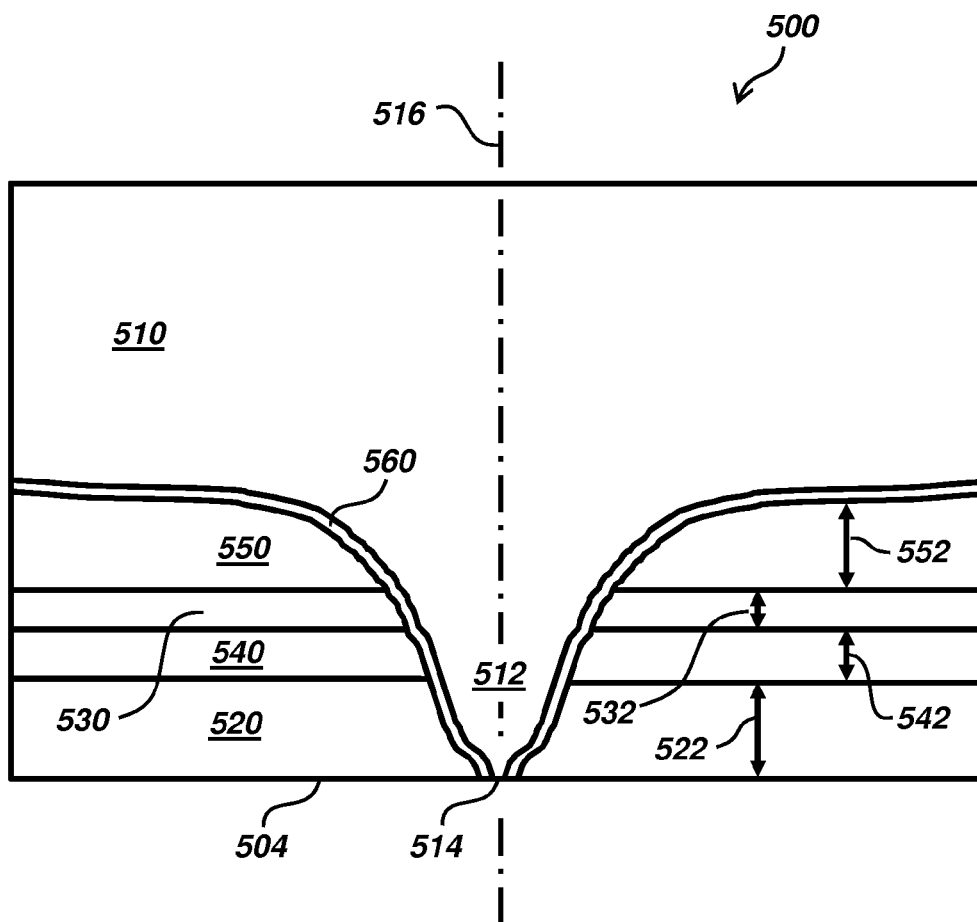


FIG. 5

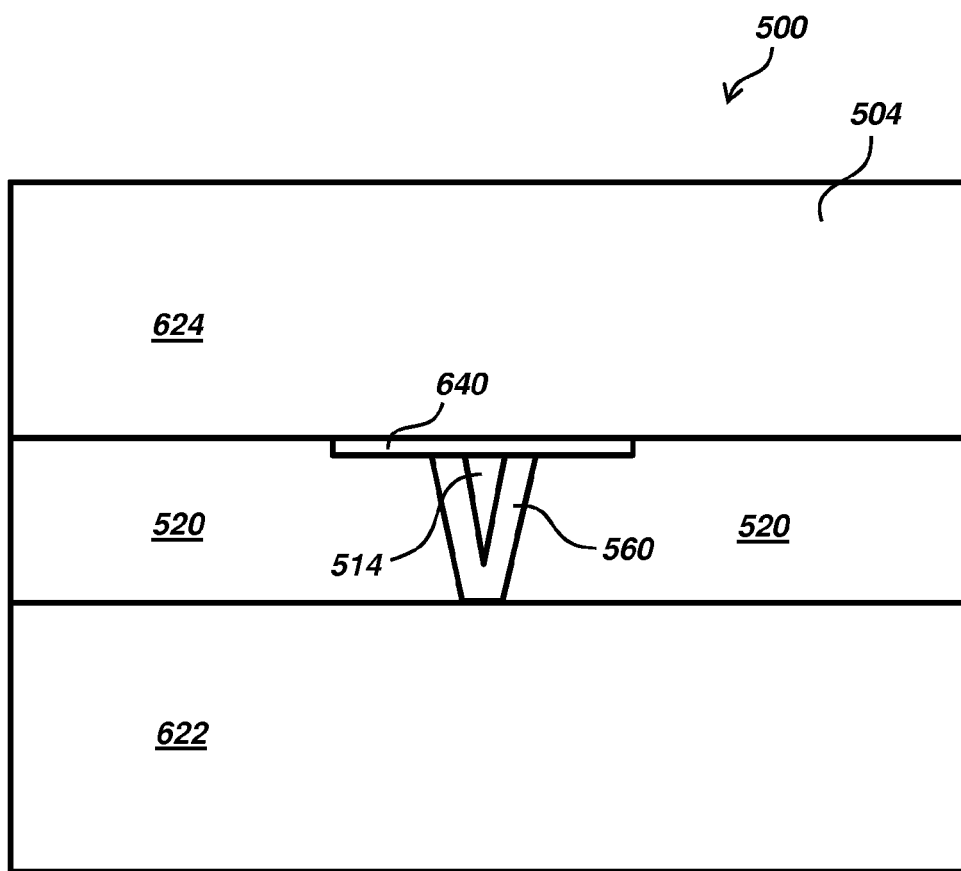


FIG. 6

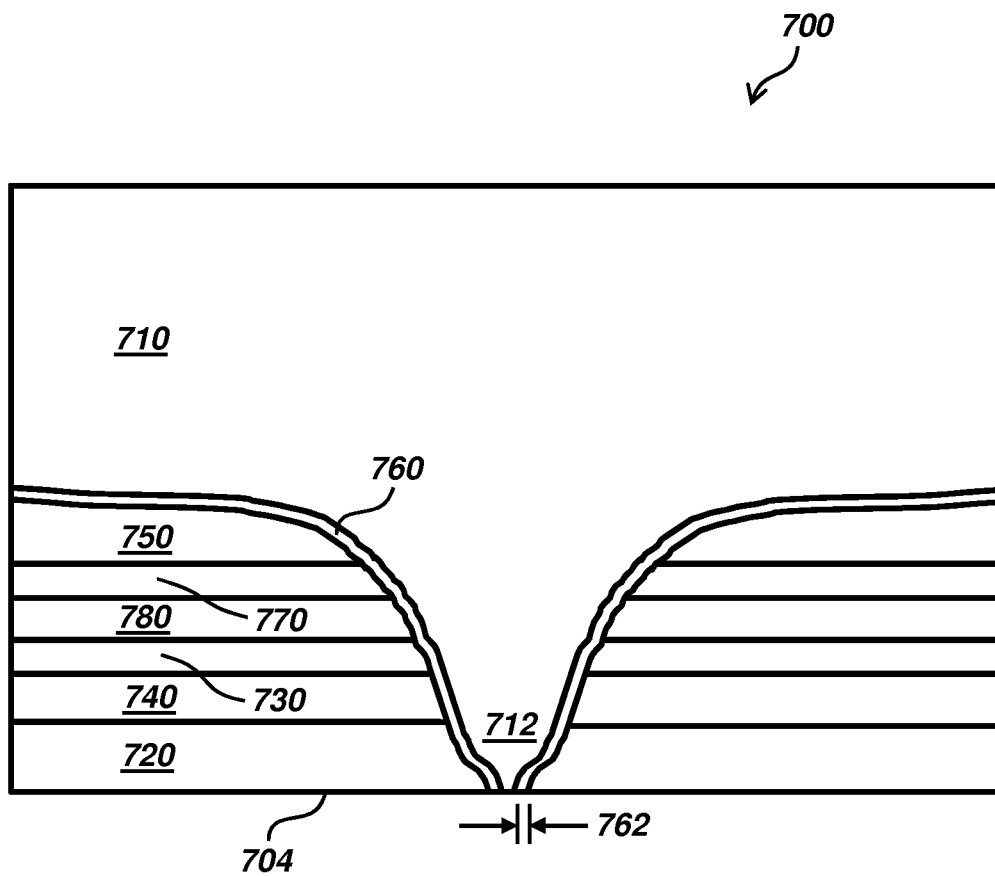


FIG. 7

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**WRITE TRANSDUCER HAVING A
MAGNETIC BUFFER LAYER SPACED
BETWEEN A SIDE SHIELD AND A WRITE
POLE BY NON-MAGNETIC LAYERS**

BACKGROUND

Information storage devices are used to retrieve and/or store data in computers and other consumer electronics devices. A magnetic hard disk drive is an example of an information storage device that includes one or more magnetic heads that can both read and write, but other information storage devices also include heads—sometimes including heads that cannot write.

In a magnetic hard disk drive, the head typically comprises a body called a “slider” that carries a magnetic transducer on its trailing end. The magnetic transducer typically comprises a writer and a read element. The magnetic transducer’s writer may be of a longitudinal or perpendicular design, and the read element of the magnetic transducer may be inductive or magnetoresistive. In a magnetic hard disk drive, the transducer is typically supported in very close proximity to a spinning magnetic disk by a hydrodynamic air bearing. As a motor rotates the magnetic disk, the hydrodynamic air bearing is formed between an air bearing surface of the slider of the head and a surface of the magnetic disk. The thickness of the air bearing at the location of the transducer is commonly referred to as the “mechanical flying height.”

The magnetic disk typically includes several layers near its surface. Information is stored magnetically in a hard magnetic layer. A protective layer including carbon typically covers the hard magnetic layer for wear and corrosion resistance. The hard magnetic layer is typically supported by one or more underlayers with desired surface and/or properties. For example, in perpendicular recording applications, a magnetically soft underlayer may help channel magnetic flux beneath the hard magnetic layer. The magnetic transducer of the head and the hard magnetic layer of the disk are typically separated by both the air bearing and the disk protective layer(s). This separation is typically referred to as the “magnetic head-disk spacing,” the “magnetic spacing,” or the “magnetic flying height.”

Modern magnetic transducers may include a magnetic shield to shunt write fields in the off track direction, thus facilitating high track density magnetic recording. However, the presence of the side shields may worsen wide area track erasure (“WATER”) due to excessive off track write field and interactions with the domain walls of the side shield. To reduce WATER and reduce off track writing, a side shield having a longer throat height is preferred. However, to reduce write field rise time and increase data rate for writing on track, a side shield having a shorter throat height is preferred.

Accordingly, what is needed in the art is a shielded write transducer design that improves the engineering trade-off between off-track and on-track writing performance.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a top perspective view of a disk drive information storage device that is capable of including an embodiment of the present invention, with the top cover removed to reveal internal components.

FIG. 2 depicts a distal end of a head gimbal assembly that includes a head that is capable of including an embodiment of the present invention.

FIG. 3 is a schematic illustration (not to scale) of a magnetic head “flying” over a magnetic disk, with disk layer

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thicknesses, slider flying height, and slider pitch angle, all greatly exaggerated so that those microscopic quantities can be discernable in the illustration.

FIG. 4 is a side cross-sectional schematic illustration (not necessarily to scale) of a shielded pole magnetic head transducer in operation over a magnetic disk, according to the prior art, with disk layer thicknesses and slider flying height greatly exaggerated so as to be discernable in the illustration.

FIG. 5 is a rear cross-sectional view of a write transducer according to an embodiment of the present invention.

FIG. 6 is an air bearing surface view of a write transducer capable of including an embodiment of the present invention.

FIG. 7 is a rear cross-sectional view of a write transducer according to another embodiment of the present invention.

DETAILED DESCRIPTION OF EXAMPLE
EMBODIMENTS

FIG. 1 is a top perspective view of a disk drive 100 that is capable of including an embodiment of the present invention, with the top cover removed to reveal internal components. The disk drive 100 includes a disk drive base 102 and two annular magnetic disks 104. The disk drive 100 further includes a spindle 106, rotatably mounted on the disk drive base 102, for rotating the disks 104. The rotation of the disks 104 establishes air flow through recirculation filter 108. In other embodiments, disk drive 100 may have only a single disk, or alternatively, more than two disks.

The disk drive 100 further includes an actuator 116 that is pivotably mounted on disk drive base 102. Voice coil motor 112 pivots the actuator 116 through a limited angular range so that at least one head gimbal assembly (HGA) 114 is desirably positioned relative to one or more tracks of information on a corresponding one of the disks 104. In the embodiment of FIG. 1, the actuator 116 includes three arms upon which four HGAs 114 are attached, each corresponding to a surface of one of the two disks 104. However in other embodiments fewer or more HGAs 114 may be included depending on the number of disks 104 that are included and whether the disk drive 100 is depopulated.

Each HGA 114 preferably includes a head 150 for reading and writing from/to one of the disks 104. The head 150 may perform various functions and contain various microscopic structures such as a read transducer for reading data, a write transducer for writing data, a microactuator, a heater, a laser, a lapping guide, etc. The actuator 116 may occasionally be latched at an extreme angular position within the limited angular range, by latch 120. Electrical signals to/from the HGAs 114 are carried to other drive electronics via a flexible printed circuit (FPC) that includes a flex cable 122 (preferably including a preamplifier circuit) and flex cable bracket 124.

FIG. 2 depicts the distal end of a head gimbal assembly (HGA) 260 that includes a head 270 that is capable of including an embodiment of the present invention. In FIG. 2, the HGA 260 includes load beam 262 and a head 270. The head 270 includes a slider substrate 272 having a trailing face 268 and a leading face 276 opposite the trailing face 268. The slider substrate 272 preferably comprises AlTiC or silicon. The slider substrate 272 also includes an air bearing surface 274 that is substantially orthogonal to the trailing face 268. The head 270 includes a read/write transducer (too small to be practically shown in the view of FIG. 2, but disposed on the trailing face 268). In certain embodiments, the read/write transducer is preferably an inductive magnetic write transducer merged with a magneto-resistive read transducer. The purpose of the load beam 262 is to provide vertical compliance for the head 270 to follow vertical undulations of the

surface of a disk (e.g. disk **104** of FIG. **1**) as it rotates, and to preload the air bearing surface **274** of the head **270** against the disk surface by a preload force that is commonly referred to as the “gram load.”

The HGA **260** also includes a laminated flexure **264** attached to the load beam **262**. The read head **270** is attached to a tongue **266** of the laminated flexure **264**. A first purpose of the laminated flexure **264** is to provide compliance for the read head **270** to follow pitch and roll angular undulations of the surface of the disk (e.g. disk **104**) as it rotates, while restricting relative motion between the read head **270** and the load beam **262** in the lateral direction and about a yaw axis. A second purpose of the laminated flexure **264** is to provide a plurality of electrical paths to facilitate signal transmission to/from the read head **270**.

For that second purpose, the laminated flexure **264** includes a plurality of electrically conductive traces **278** that are defined in an electrically conductive layer **286**, and that are isolated from a supporting structural layer **282** by a dielectric layer **284** that is disposed between the structural layer **282** and the electrically conductive layer **286**. The plurality of electrically conductive traces **278** of the flexure **264** may be electrically connected to a first plurality of electrically conductive trailing connection pads **290** on the trailing face **268** of the read head **270**, by a plurality of 90° bonds **288**.

In the example of FIG. **2**, the first plurality of electrically conductive trailing connection pads **290** may optionally comprise copper or gold, and the plurality of 90° bonds **288** preferably comprises solder or gold. The conductive layer **286** and the conductive traces **278** may comprise copper, the structural layer **282** may comprise stainless steel and/or another suitable structural material, and the dielectric layer **284** may comprise polyimide, for example. In various regions of the laminated flexure **264**, one or more of the layers may be absent (e.g. removed by etching).

FIG. **3** is a schematic illustration (not to scale) of a magnetic head **200** “flying” over a magnetic disk **250**, with disk layer thicknesses, slider flying height, and slider pitch angle, all greatly exaggerated so that those microscopic quantities can be discernable in the illustration. Now referring to FIG. **3**, head **200** comprises a transducer **202** for at least writing information to a hard magnetic layer **254** of the disk **250**. The transducer **202** is capable of including one or more magnetic shielding structures according to an embodiment of the present invention.

In certain embodiments, the transducer **202** is a merged thin film magnetic transducer comprising an inductive writer and magneto resistive read element. In such embodiments, the magneto resistive element may be a giant magneto resistive element (GMR) or tunneling magneto resistive element (TMR). In such embodiments, the writer may be a perpendicular magnetic recording (PMR) writer, and in such cases the disk will preferably include a soft magnetic underlayer **252** beneath the hard magnetic layer **254**.

Head **200** also comprises a slider **204**, which may be fabricated from a ceramic material such as alumina titanium carbide. Slider **204** includes an air bearing surface (ABS) **206**, which may be formed by etching or ion milling according to dimensions that may be defined by use of a mask. The slider **204** defines a longitudinal axis **214** normal to the trailing face **208**, defines a write pole axis **212** normal to the ABS **206**, and defines a lateral axis (in and out of the page in FIG. **2**) that is normal to both the longitudinal axis **214** and the write pole axis **212**.

Note that in FIG. **3** the thicknesses of a protective layer **256** on the disk, the hard magnetic layer **254**, and the soft magnetic underlayer **252**, have been exaggerated to be discernable

in the illustration. Also, a magnetic spacing **280** (between the head transducer **202** and the hard magnetic layer **254** of the disk) has been greatly exaggerated in FIG. **2** so that the slider flying height and the slider pitch angle can be discerned in the illustration. However, during operation of a practical disk drive, the slider flying height and slider pitch angle would both be very small quantities such that the plane of the ABS **206** and the longitudinal axis **214** would both be substantially parallel to the hard magnetic layer **254**, and such that both the trailing face **208** and the write pole axis **212** would be substantially normal to the hard magnetic layer **254**.

FIG. **4** is a side cross-sectional schematic illustration (not necessarily to scale) of a shielded pole magnetic head transducer **350** in operation over a magnetic disk **250**, according to the prior art, with disk layer thicknesses and slider flying height greatly exaggerated so as to be discernable in the illustration. The transducer **350** of FIG. **4** includes a perpendicular recording writer that includes conductive coil turns **318**, a main pole **310**, and two return poles **314** and **360**. The main pole **310** has a relatively small cross section near the ABS and is constructed of a soft ferromagnetic material having high magnetic moment, such as FeNi or CoFe (e.g. Co₃₀Fe₇₀). The two return poles **314** and **360** are also constructed of a high-permeability soft ferromagnetic material, and have a cross section near the ABS plane **302** that is significantly larger than that of the main pole **310**.

Consequently, the magnetic flux **330** that passes between the main pole **310** and the soft magnetic under layer **252** (and through the air bearing and protective layer **256**), when a write current is passed through coil turns **318**, has a high enough flux density to flip magnetic domains in the hard magnetic layer **254**. However, the magnetic flux that passes between the soft magnetic underlayer **252** and the two return poles **314** and **360** have too low a flux density to flip magnetic domains in the hard magnetic layer **254**. A closed high-permeability path for the magnetic flux is completed by back gap **316** and yoke piece **312** which are also constructed of a soft ferromagnetic material.

In the example of FIG. **4**, the read sensor **304** may be a current perpendicular to plane (CPP) giant magnetoresistive (GMR) sensor, a current in plane (CIP) GMR sensor, or a tunnel junction sensor (TMR), etc. The read sensor **304** is located between and insulated from first and second reader magnetic shields **306**, **308**. The reader magnetic shields **306**, **308**, which comprise a soft magnetic material such as CoFe or NiFe, have high enough permeability to channel undesired magnetic fields (e.g. stray fields and/or fields from nearby data tracks) away from the read sensor **304**, so that the read sensor **304** predominantly detects only the desired data track located between the reader shields **306**, **308**.

In the example of FIG. **4**, conductive coil turns **318** are surrounded by an electrically insulating material **320** that electrically insulates them from one another and from the surrounding magnetic yoke structures (e.g. return poles **314**, **360**, main pole **310**, back gap **316**, and yoke piece **312**). The regions surrounding the read element **304** and reader shields **306**, **308** also may comprise a non-ferromagnetic and electrically insulating material **332** (e.g. alumina).

In the example of FIG. **4**, the tip of the main pole **310** terminates in the ABS plane **302** so that the magnetic spacing **280** is equal to the flying height plus the thickness of disk protective layer **256**. However in certain other examples the transducer **350** may be marginally recessed from the plane of the ABS due to lapping. For example, the transducer **350** may be recessed from the ABS plane **302** by approximately 2.5 nanometers due to lapping (thereby increasing the magnetic spacing **280** by approximately 2.5 nanometers). The trans-

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ducer 350 may also slightly protrude beyond the ABS plane due to thermal expansion (e.g. thermal pole tip protrusion and/or thermal dynamic transducer actuation), thereby reducing the magnetic spacing 280 by the amount of protrusion.

In the example of FIG. 4, the return pole 360 may also function as a leading or trailing writer shield, and its function in that regard may be enhanced by the optional addition of an S3 shield 370 which may extend longitudinally from the second return pole 360 towards the main pole 310.

FIG. 5 is a rear cross-sectional view of a write transducer 500 according to certain embodiments of the present invention. FIG. 6 is an air bearing surface view of the write transducer 500. Now referring to FIGS. 5 and 6, the write transducer 500 includes a write yoke 510 comprising a first ferromagnetic material (e.g. $\text{Co}_{30}\text{Fe}_{70}$ or other high-permeability ferromagnetic composition). A write pole 512 protrudes from the write yoke 510 towards an air bearing surface 504 of the write transducer 500, and terminates at a pole tip 514 (adjacent to the air bearing surface 504) that may optionally have a roughly triangular, rectangular, or trapezoidal cross sectional shape in a plane parallel to the air bearing surface 504. In certain embodiments, the write pole 512 may protrude from the write yoke 510 along a write pole axis 516 that is optionally normal to the air bearing surface 504.

In the embodiment of FIGS. 5 and 6, the write transducer 500 includes a side shield 520 comprising a second ferromagnetic material (e.g. $\text{Ni}_{30}\text{Fe}_{70}$, $\text{Co}_{69}\text{Ni}_{14}\text{Fe}_{17}$, $\text{Co}_{50}\text{Ni}_{15}\text{Fe}_{35}$, or other high-permeability ferromagnetic composition). The side shield 520 may span a side shield throat height 522 that is optionally in the range of 50 nm to 600 nm, as measured in a direction normal to the air bearing surface 504.

In the embodiment of FIGS. 5 and 6, the pole tip 514 may be separated from the side shield 520 by a side gap comprising a non-magnetic metal layer 560 having a thickness in the range of 10 nm to 100 nm. In certain embodiments, the non-magnetic metal layer 560 of the side gap optionally may comprise ruthenium, tantalum, or copper.

In the embodiment of FIGS. 5 and 6, the write transducer 500 includes a ferromagnetic buffer layer 530 disposed between the write yoke 510 and the side shield 520. The ferromagnetic buffer layer 530 preferably extends in a direction normal to the air bearing surface 504 by a buffer layer throat height 532 in the range of 10 nm to 500 nm. The ferromagnetic buffer layer may comprise a third ferromagnetic material that preferably has a magnetic moment of no less than 1.6 Tesla. In certain embodiments, the third ferromagnetic material of the buffer layer 530 optionally may have a magnetic moment that is 0.6 to two times that of the second ferromagnetic material of the side shield 520. In certain embodiments, the third ferromagnetic material of the buffer layer 530 optionally may have the same composition as the second ferromagnetic material of the side shield 520.

In the embodiment of FIGS. 5 and 6, the write transducer 500 includes a first non-magnetic layer 540 disposed between the side shield 520 and the ferromagnetic buffer layer 530. Hence, the ferromagnetic buffer layer 530 is spaced from the side shield 520 by no less than a thickness 542 of the first non-magnetic layer 540. The thickness 542 of the first non-magnetic layer 540 optionally may be in the range of 10 nm to 300 nm, as measured in a direction normal to the air bearing surface 504.

In the embodiment of FIGS. 5 and 6, the write transducer 500 includes a second non-magnetic layer 550 disposed between the ferromagnetic buffer layer 530 and the write yoke 510. Hence, the ferromagnetic buffer layer 530 is spaced from the write yoke 510 by no less than a thickness 552 of the second non-magnetic layer 550. The thickness 552 of the

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second non-magnetic layer 550 optionally may be in the range of 100 nm to 1 μm , as measured in a direction normal to the air bearing surface 504. In certain embodiments, each of the first and second non-magnetic layers 540, 550 may optionally comprise a ceramic material such as aluminum oxide, titanium oxide, or magnesium oxide.

In certain embodiments, the write transducer 500 may include a ferromagnetic wrap-around shield structure that includes the side shield 520. Such a ferromagnetic wrap-around shield structure may surround the write pole 512 in a plane parallel to the air bearing surface 504. For example, as shown in FIG. 6, a wrap-around shield structure may include the side shield 520, a leading shield 622, and a trailing shield 624, essentially surrounding the writer pole tip 514. The leading shield 622 and the trailing shield 624 each comprises a high-permeability ferromagnetic material, for example, optionally the same as that of the side shield 520. FIG. 6 also depicts a conventional trailing gap 640.

The write transducer 500 described with reference to FIGS. 5 and 6 may advantageously enable the side shield 520 to have a longer throat height 522 in certain embodiments, without excessively increasing write field rise time or excessively degrading data rate for writing on track. Hence, the write transducer 500 of FIGS. 5 and 6 may advantageously shunt write fields in the off track direction, and avoid wide area track erasure ("WATER") that might otherwise be caused by excessive off track write field and interactions with the domain walls of the side shield 520. In this way, the design of the write transducer 500 may improve the engineering trade-off between off-track and on-track writing performance.

In certain embodiments, the ferromagnetic buffer layer 530 may be just one of a plurality of ferromagnetic buffer layers disposed between the write yoke 510 and the side shield 520, each separated from another by a non-magnetic decoupling layer. For example, FIG. 7 is a rear cross-sectional view of a write transducer 700 according to one such embodiment of the present invention.

In the embodiment of FIG. 7, the write transducer 700 includes a high-permeability ferromagnetic write yoke 710 and a write pole 712 protruding from the write yoke 710 towards an air bearing surface 704 of the write transducer 700. The write transducer 700 includes a high-permeability ferromagnetic side shield 720 that may be separated from the pole tip 712 by a side gap comprising a non-magnetic metal layer 760 having a thickness 762 in the range of 10 nm to 100 nm. In certain embodiments, the non-magnetic metal layer 760 of the side gap optionally may comprise ruthenium, tantalum, or copper.

In the embodiment of FIG. 7, the write transducer 700 includes two or more high-permeability ferromagnetic buffer layers 730 and 770 disposed between the write yoke 710 and the side shield 720. Each of the ferromagnetic buffer layers 730 and 770 preferably extends in a direction normal to the air bearing surface 704 by a buffer layer throat height in the range of 10 nm to 500 nm. Each of the ferromagnetic buffer layers 730 and 770 may optionally comprise a similar or the same ferromagnetic material composition (e.g. $\text{Ni}_{30}\text{Fe}_{70}$, $\text{Co}_{69}\text{Ni}_{14}\text{Fe}_{17}$, $\text{Co}_{50}\text{Ni}_{15}\text{Fe}_{35}$, etc.), however, it is also contemplated that one or more of a plurality of ferromagnetic buffer layers may comprise one or more different ferromagnetic material compositions. It is not necessary that they be the same, in certain embodiments.

In the embodiment of FIG. 7, the write transducer 700 includes a first non-magnetic layer 740 disposed between the side shield 720 and the ferromagnetic buffer layer 730. Hence, each of the ferromagnetic buffer layer 730 and 770 is spaced from the side shield 720 by no less than a thickness of

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the first non-magnetic layer **740**. In the embodiment of FIG. 7, the write transducer **700** also includes a second non-magnetic layer **750** disposed between the ferromagnetic buffer layer **770** and the write yoke **710**. Hence, each of the ferromagnetic buffer layers **730** and **770** is spaced from the write yoke **710** by no less than a thickness of the second non-magnetic layer **750**. In certain embodiments, each of the first and second non-magnetic layers **740**, **750** may optionally comprise a ceramic material such as aluminum oxide, titanium oxide, or magnesium oxide.

In the embodiment of FIG. 7, the write transducer **700** also includes a non-magnetic decoupling layer **780** disposed between the ferromagnetic buffer layers **730** and **770**. The non-magnetic decoupling layer **780** preferably has a thickness in the range of 10 nm to 300 nm (as measured in a direction normal to the air bearing surface **704**), so as to preferably substantially magnetically decouple the ferromagnetic buffer layers **730** and **770**.

The write transducer **700** described with reference to FIG. 7 may advantageously enable the side shield **720** to have a longer throat height in certain embodiments, without excessively increasing write field rise time or excessively degrading data rate for writing on track. Hence, the write transducer **700** of FIG. 7 may advantageously shunt write fields in the off track direction, and avoid WATER that might otherwise be caused by excessive off track write field and interactions with the domain walls of the side shield **720**. In this way, the design of the write transducer **700** may improve the engineering trade-off between off-track and on-track writing performance.

In the foregoing specification, the invention is described with reference to specific exemplary embodiments, but those skilled in the art will recognize that the invention is not limited to those. It is contemplated that various features and aspects of the invention may be used individually or jointly and possibly in a different environment or application. The specification and drawings are, accordingly, to be regarded as illustrative and exemplary rather than restrictive. For example, the word “preferably,” and the phrase “preferably but not necessarily,” are used synonymously herein to consistently include the meaning of “not necessarily” or optionally. “Comprising,” “including,” and “having,” are intended to be open-ended terms.

What is claimed is:

1. A write transducer comprising:

a write yoke comprising a first ferromagnetic material and including a write pole protruding from the write yoke towards an air bearing surface of the write transducer;
a side shield comprising a second ferromagnetic material;
a ferromagnetic buffer layer disposed between the write yoke and the side shield, the ferromagnetic buffer layer comprising a third ferromagnetic material;
a first non-magnetic layer disposed between the side shield and the ferromagnetic buffer layer, the ferromagnetic buffer layer being spaced from the side shield by no less than a thickness of the first non-magnetic layer; and
a second non-magnetic layer disposed between the ferromagnetic buffer layer and the write yoke, the ferromagnetic buffer layer being spaced from the write yoke by no less than a thickness of the second non-magnetic layer;
wherein the ferromagnetic buffer layer extends in a direction normal to the air bearing surface by a buffer layer throat height in the range of 10 nm to 500 nm, and wherein the third ferromagnetic material has a magnetic moment that is 0.6 to two times that of the second ferromagnetic material.

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2. The write transducer of claim 1 wherein the write pole protrudes from the write yoke along a write pole axis that is normal to the air bearing surface.

3. The write transducer of claim 1 wherein the thickness of the first non-magnetic layer is in the range of 10 nm to 300 nm, as measured in a direction normal to the air bearing surface.

4. The write transducer of claim 1 wherein the thickness of the second non-magnetic layer is in the range of 100 nm to 1 μ m, as measured in a direction normal to the air bearing surface.

5. The write transducer of claim 1 wherein the side shield spans a side shield throat height in the range of 50 nm to 600 nm, as measured in a direction normal to the air bearing surface.

6. The write transducer of claim 1 wherein the write transducer is a perpendicular magnetic recording write transducer, and the first ferromagnetic material has a composition $\text{Co}_{30}\text{Fe}_{70}$.

7. The write transducer of claim 1 wherein the second ferromagnetic material has a composition selected from the group consisting of $\text{Ni}_{30}\text{Fe}_{70}$, $\text{Co}_{69}\text{Ni}_{14}\text{Fe}_{17}$, and $\text{Co}_{50}\text{Ni}_{15}\text{Fe}_{35}$.

8. The write transducer of claim 1 wherein the third ferromagnetic material has the same composition as the second ferromagnetic material.

9. The write transducer of claim 1 wherein the third ferromagnetic material has a magnetic moment of no less than 1.6 Tesla.

10. The write transducer of claim 1 wherein each of the first and second non-magnetic layers comprises aluminum oxide, titanium oxide, or magnesium oxide.

11. The write transducer of claim 1 wherein the write pole includes a pole tip disposed adjacent to the air bearing surface, the pole tip being separated from the side shield by a side gap, the side gap comprising a non-magnetic metal layer having a thickness in the range of 10 nm to 100 nm.

12. The write transducer of claim 11 wherein the pole tip has a triangular cross sectional shape in a plane parallel to the air bearing surface, and the non-magnetic metal layer comprises ruthenium, tantalum, or copper.

13. The write transducer of claim 1 further comprising a ferromagnetic wrap-around shield structure that comprises the side shield and the second ferromagnetic material, the ferromagnetic wrap-around shield structure surrounding the write pole in a plane parallel to the air bearing surface.

14. The write transducer of claim 1 wherein the ferromagnetic buffer layer is one of a plurality of ferromagnetic buffer layers disposed between the write yoke and the side shield, each separated from another by a non-magnetic decoupling layer having a thickness in the range of 10 nm to 300 nm, as measured in a direction normal to the air bearing surface.

15. A magnetic head comprising:

a slider having an air bearing surface and a trailing face approximately orthogonal to the air bearing surface;
a write transducer disposed on the trailing face, the write transducer comprising
a write yoke comprising a first ferromagnetic material and including a write pole protruding from the write yoke towards the air bearing surface;
a side shield comprising a second ferromagnetic material;
a ferromagnetic buffer layer disposed between the write yoke and the side shield, the ferromagnetic buffer layer comprising a third ferromagnetic material;
a first non-magnetic layer disposed between the side shield and the ferromagnetic buffer layer, the ferro-

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magnetic buffer layer being spaced from the side shield by no less than a thickness of the first non-magnetic layer; and

a second non-magnetic layer disposed between the ferromagnetic buffer layer and the write yoke, the ferromagnetic buffer layer being spaced from the write yoke by no less than a thickness of the second non-magnetic layer;

wherein the ferromagnetic buffer layer extends in a direction normal to the air bearing surface by a buffer layer throat height in the range of 10 nm to 500 nm, and wherein the third ferromagnetic material has a magnetic moment that is 0.6 to two times that of the second ferromagnetic material.

16. The magnetic head of claim 15 wherein the thickness of the first non-magnetic layer is in the range of 10 nm to 300 nm, as measured in a direction normal to the air bearing surface.

17. The magnetic head of claim 15 wherein the thickness of the second non-magnetic layer is in the range of 100 nm to 1 μ m, as measured in a direction normal to the air bearing surface.

18. The magnetic head of claim 15 wherein the side shield spans a side shield throat height in the range of 50 nm to 600 nm, as measured in a direction normal to the air bearing surface.

19. The magnetic head of claim 15 wherein the third ferromagnetic material has the same composition as the second ferromagnetic material.

20. The magnetic head of claim 15 wherein the third ferromagnetic material has a magnetic moment of no less than 1.6 Tesla.

21. The magnetic head of claim 15 wherein the write pole includes a pole tip disposed adjacent to the air bearing surface, the pole tip being separated from the side shield by a side gap, the side gap comprising a non-magnetic metal layer having a thickness in the range of 10 nm to 100 nm.

22. The magnetic head of claim 15 further comprising a ferromagnetic wrap-around shield structure that comprises the side shield and the second ferromagnetic material, the ferromagnetic wrap-around shield structure surrounding the write pole in a plane parallel to the air bearing surface.

23. The magnetic head of claim 15 wherein the ferromagnetic buffer layer is one of a plurality of ferromagnetic buffer layers disposed between the write yoke and the side shield,

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each separated from another by a non-magnetic decoupling layer having a thickness in the range of 10 nm to 300 nm, as measured in a direction normal to the air bearing surface.

24. A disk drive comprising:

a disk drive base;

a spindle attached to the disk drive base and defining a spindle axis of rotation;

a disk rotatably mounted on the spindle;

a head actuator attached to the disk drive base;

a magnetic head attached to the head actuator; the magnetic head comprising

a slider having an air bearing surface facing the disk, and a trailing face approximately orthogonal to the air bearing surface;

a write transducer disposed on the trailing face, the write transducer comprising

a write yoke comprising a first ferromagnetic material and including a write pole protruding from the write yoke towards the air bearing surface;

a side shield comprising a second ferromagnetic material;

a ferromagnetic buffer layer disposed between the write yoke and the side shield, the ferromagnetic buffer layer comprising a third ferromagnetic material;

a first non-magnetic layer disposed between the side shield and the ferromagnetic buffer layer, the ferromagnetic buffer layer being spaced from the side shield by no less than a thickness of the first non-magnetic layer; and

a second non-magnetic layer disposed between the ferromagnetic buffer layer and the write yoke, the ferromagnetic buffer layer being spaced from the write yoke by no less than a thickness of the second non-magnetic layer;

wherein the ferromagnetic buffer layer extends in a direction normal to the air bearing surface by a buffer layer throat height in the range of 10 nm to 500 nm, and wherein the third ferromagnetic material has a magnetic moment that is 0.6 to two times that of the second ferromagnetic material.

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